Future of the search for composite Higgs models and related exotic particles at colliders

Patrick Fox

Fermilab

Future of the search for *not supersymmetry* at colliders

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July 4th.....

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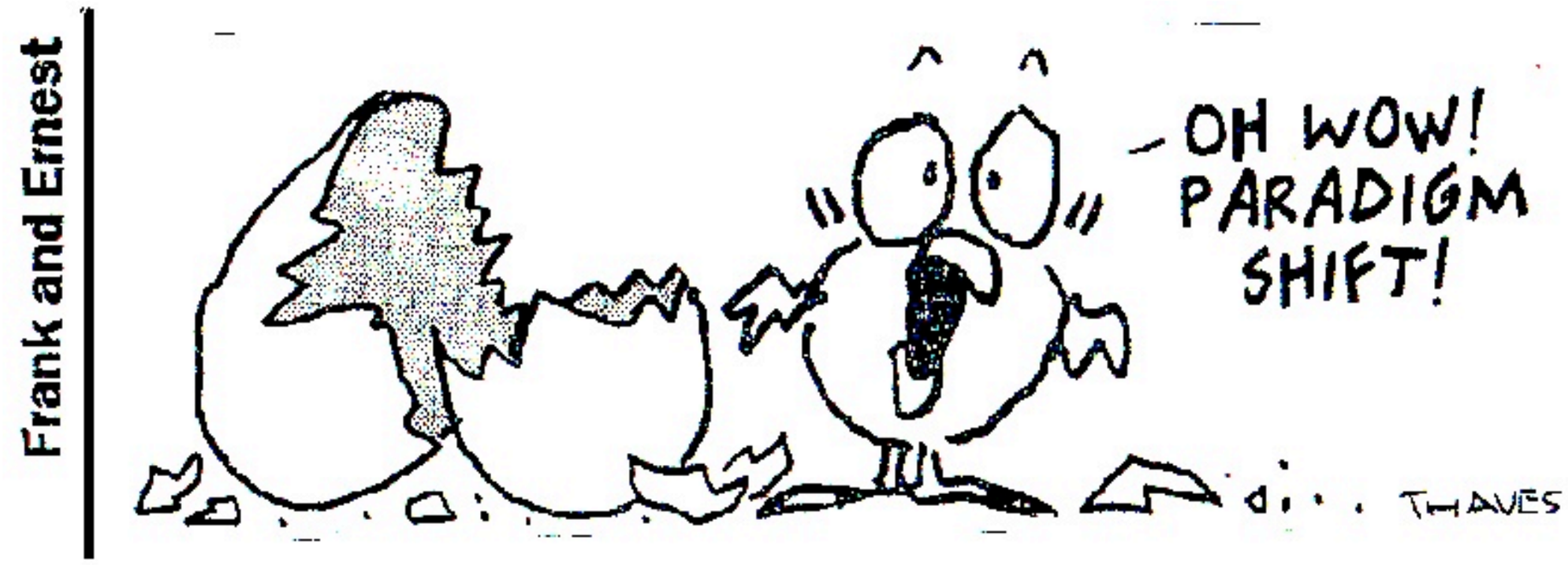

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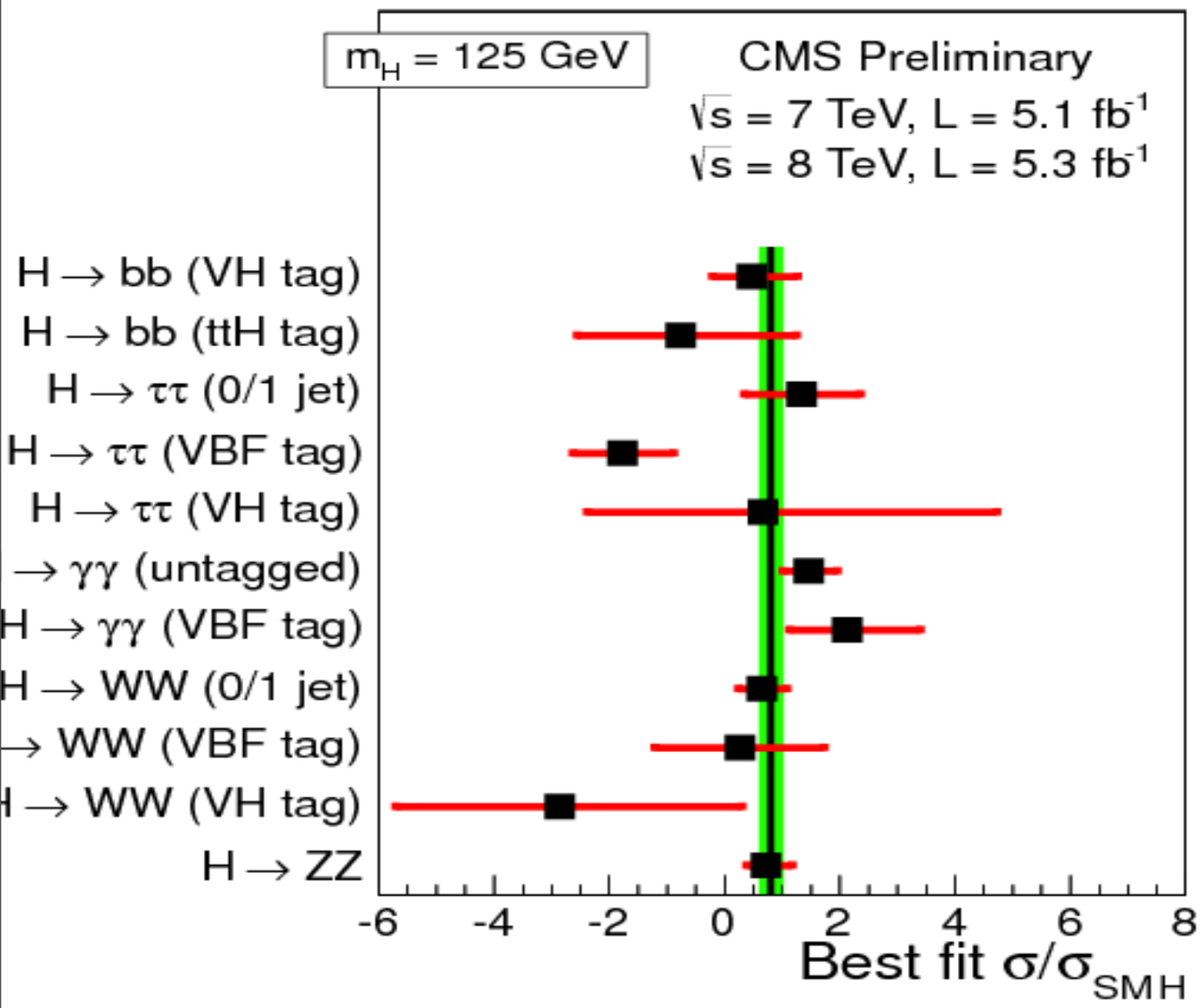

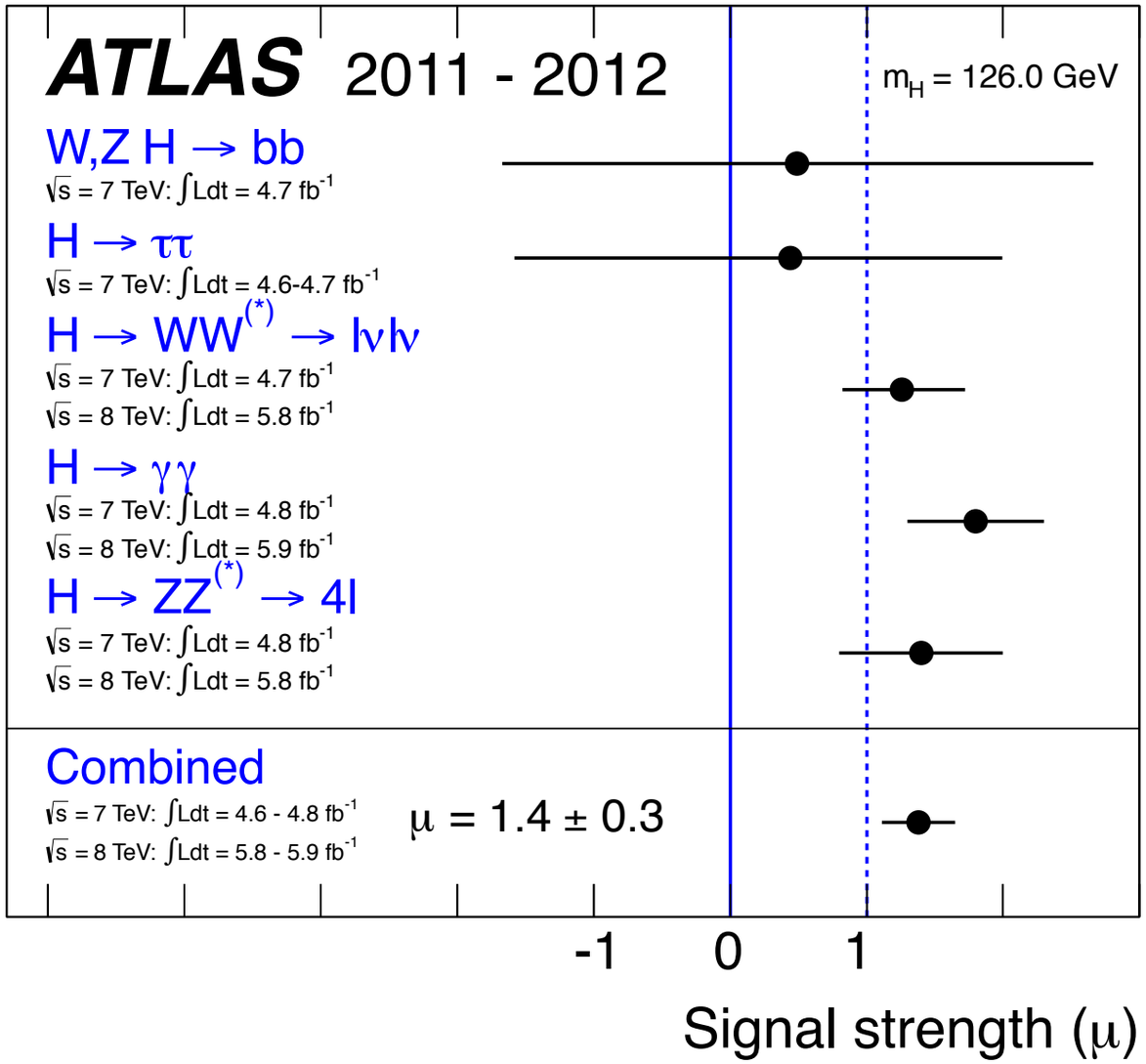

SM Higgs?
SM-like SUSY Higgs?
Too heavy for SUSY?

Leptophobic/Fermiophobic?
Exotic BR's (e.g. DM)?
Total width?

What keeps the Higgs light?

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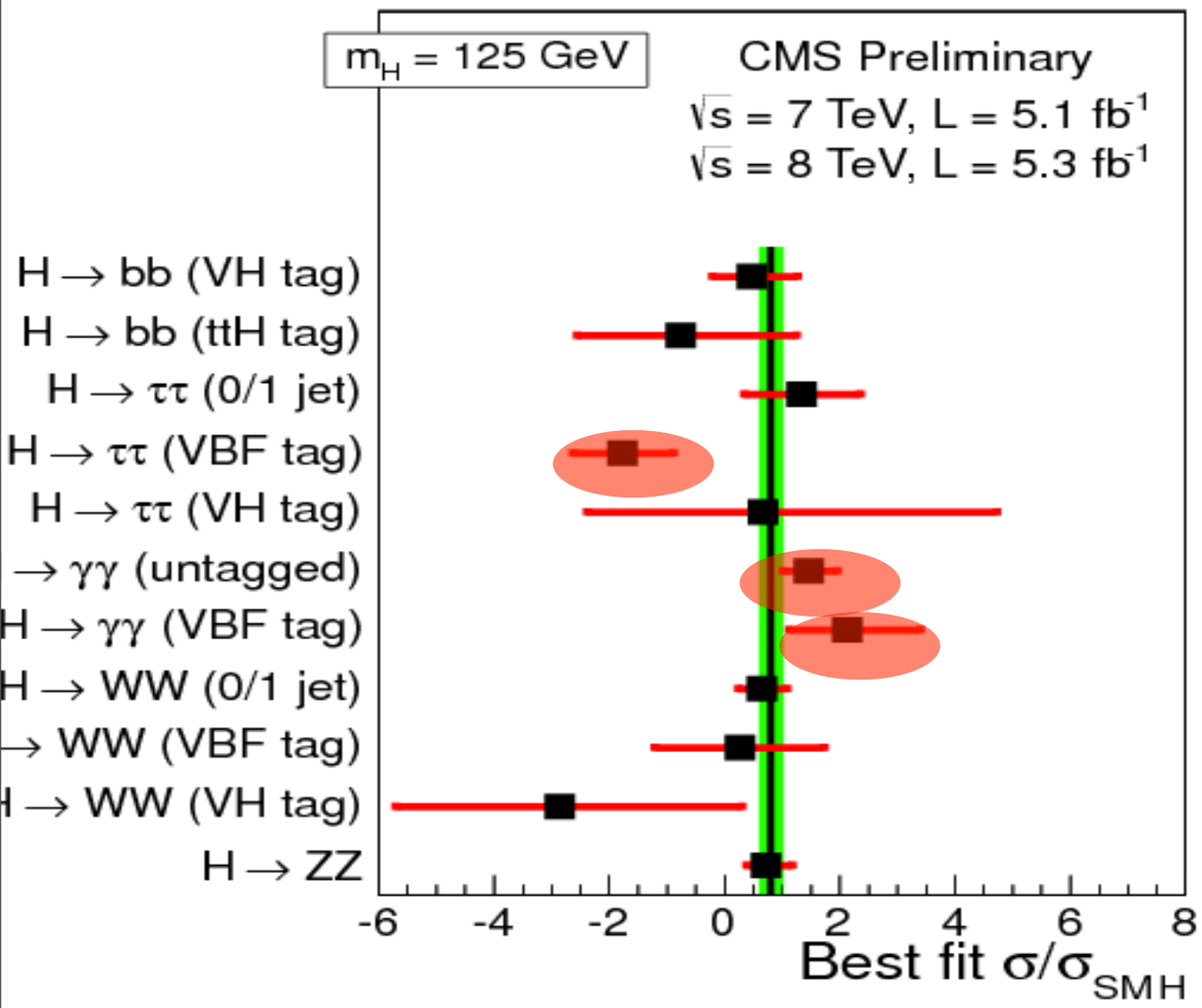

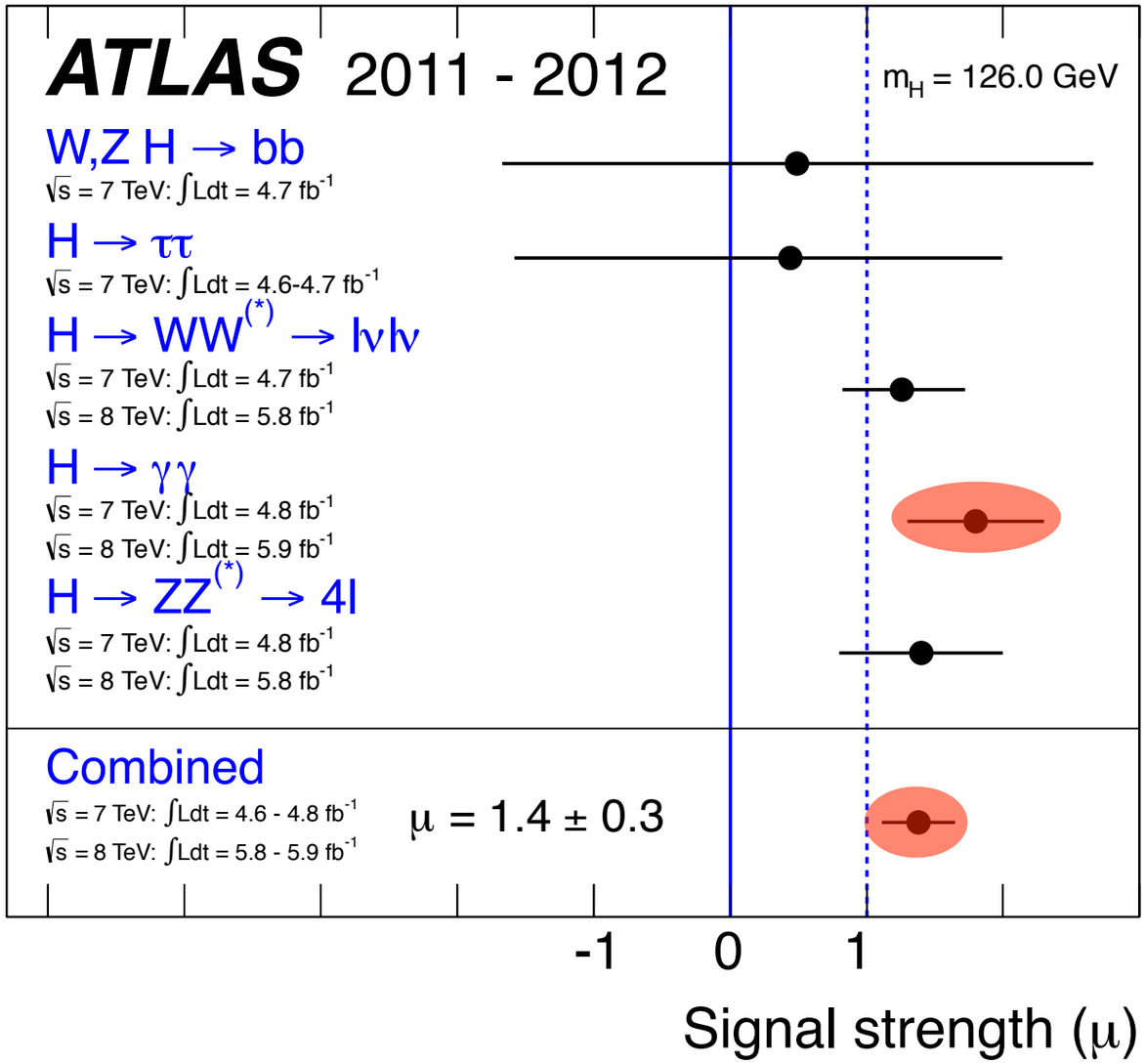

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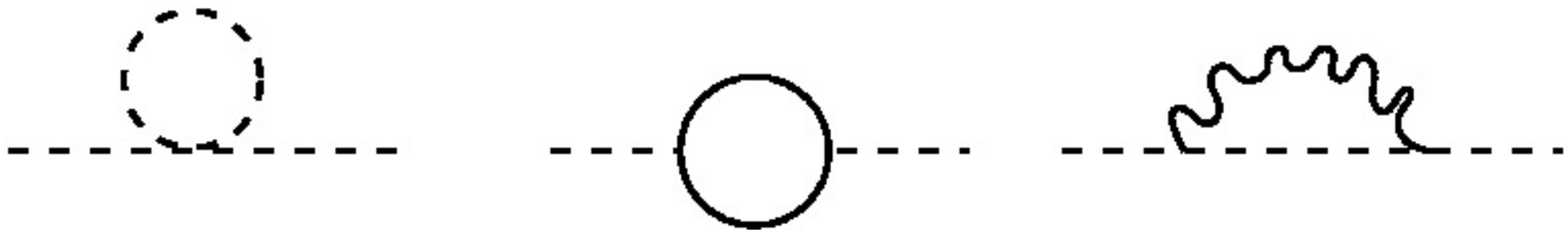
Quadratic divergences in the Higgs sector



SUSY introduces superpartners to cutoff divergences, must be around the weak scale

$$\delta\lambda \to \Delta m_h^2 = \frac{3y_t^2}{4\pi^2} m_t^2 \log\left(\frac{m_{\tilde{t}}^2}{m_t^2}\right)$$

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SUSY little hierarchy problem

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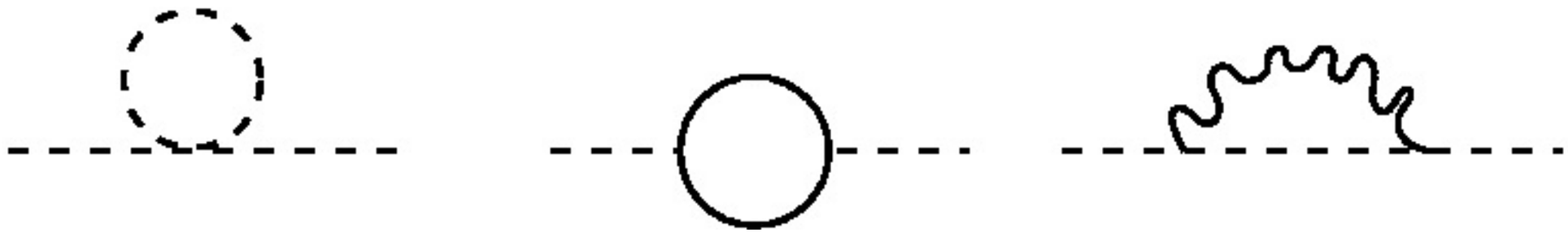

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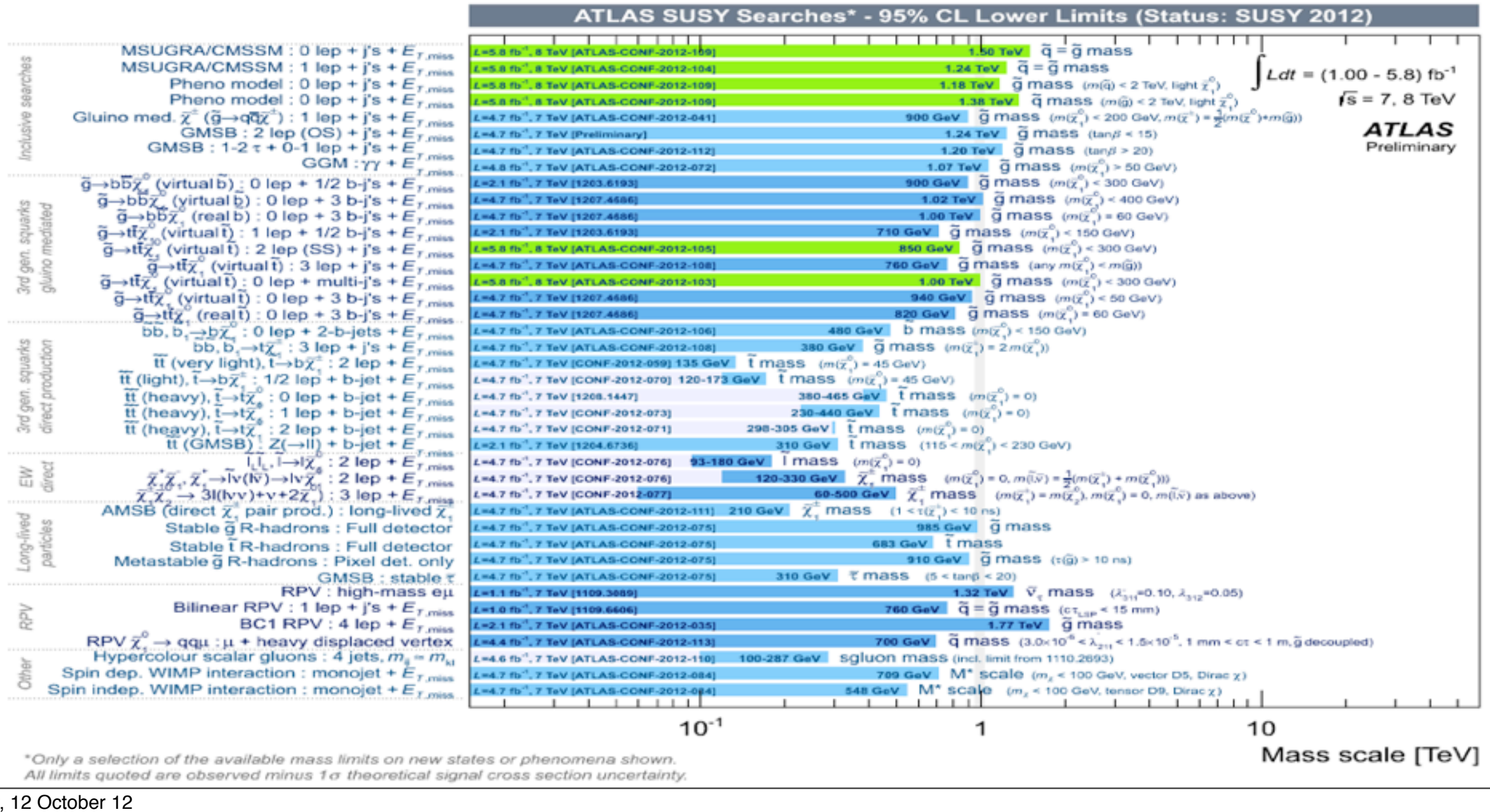
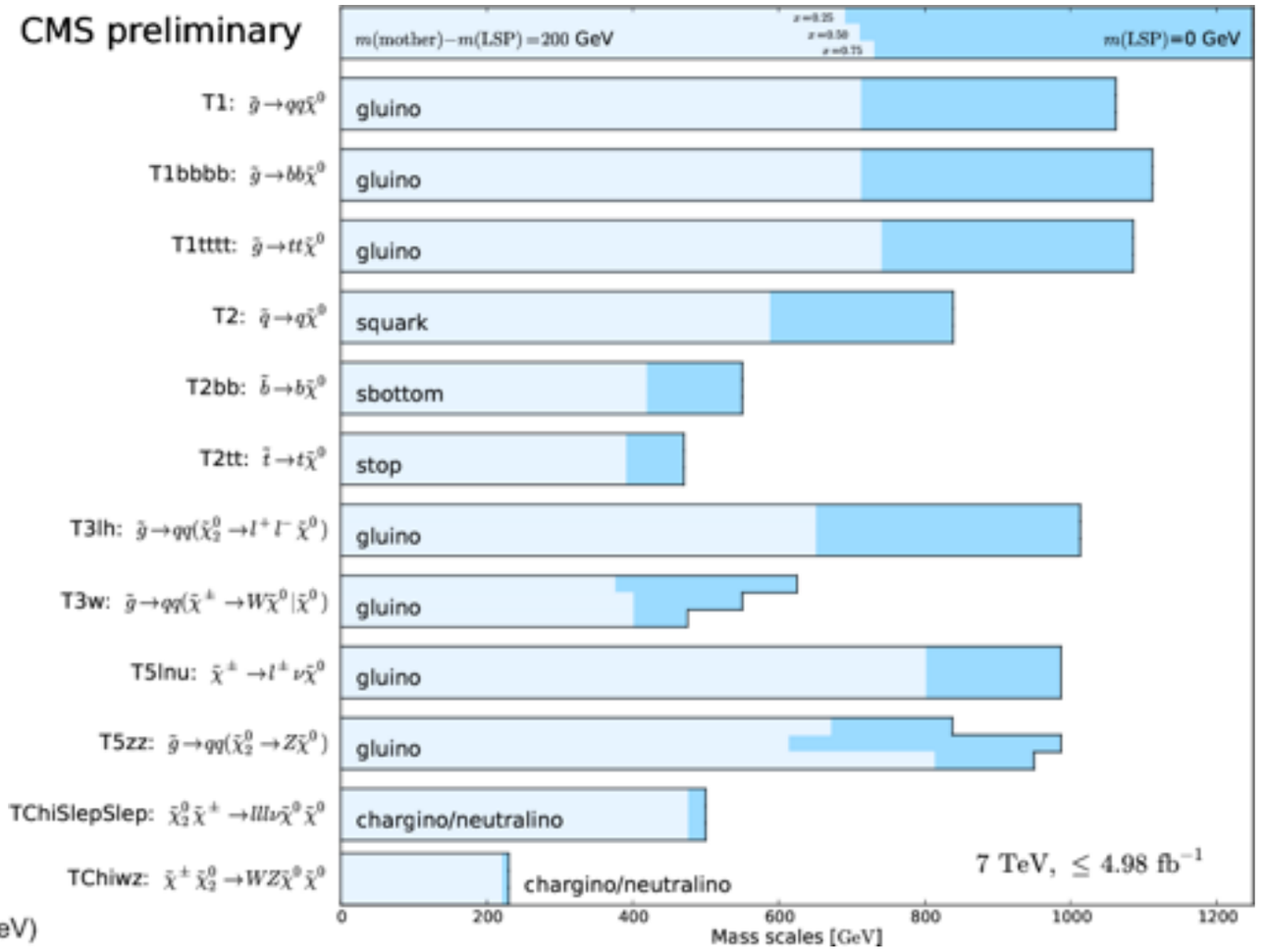
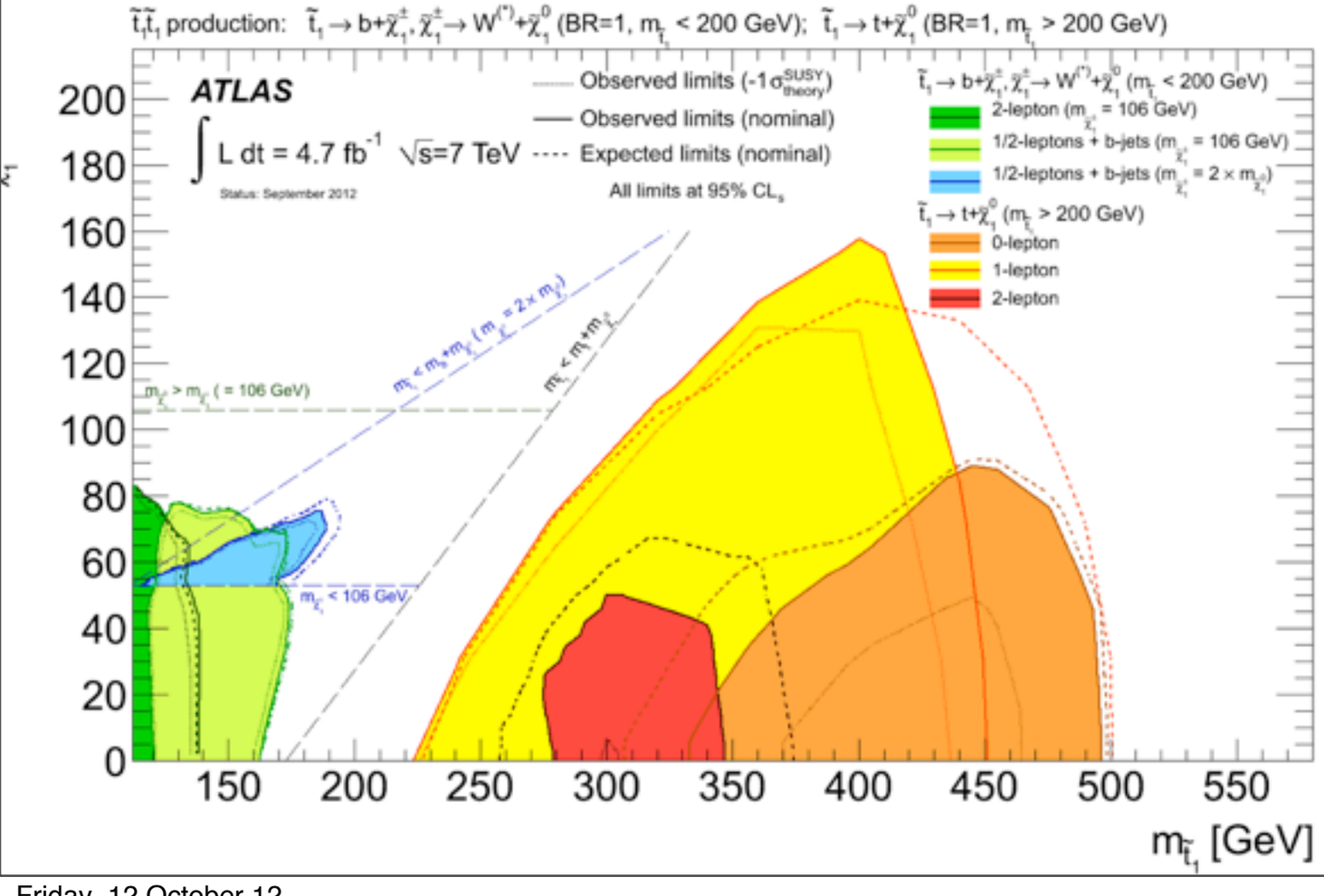


Stop searches are key

Not your advisor's MSSM?

eg NMSSM, MRSSM,
Stealth SUSY, RPV,
(X)MSSM...





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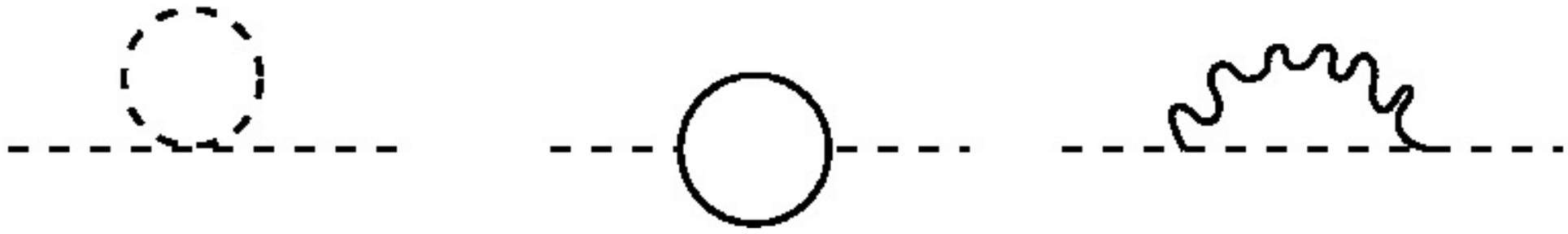


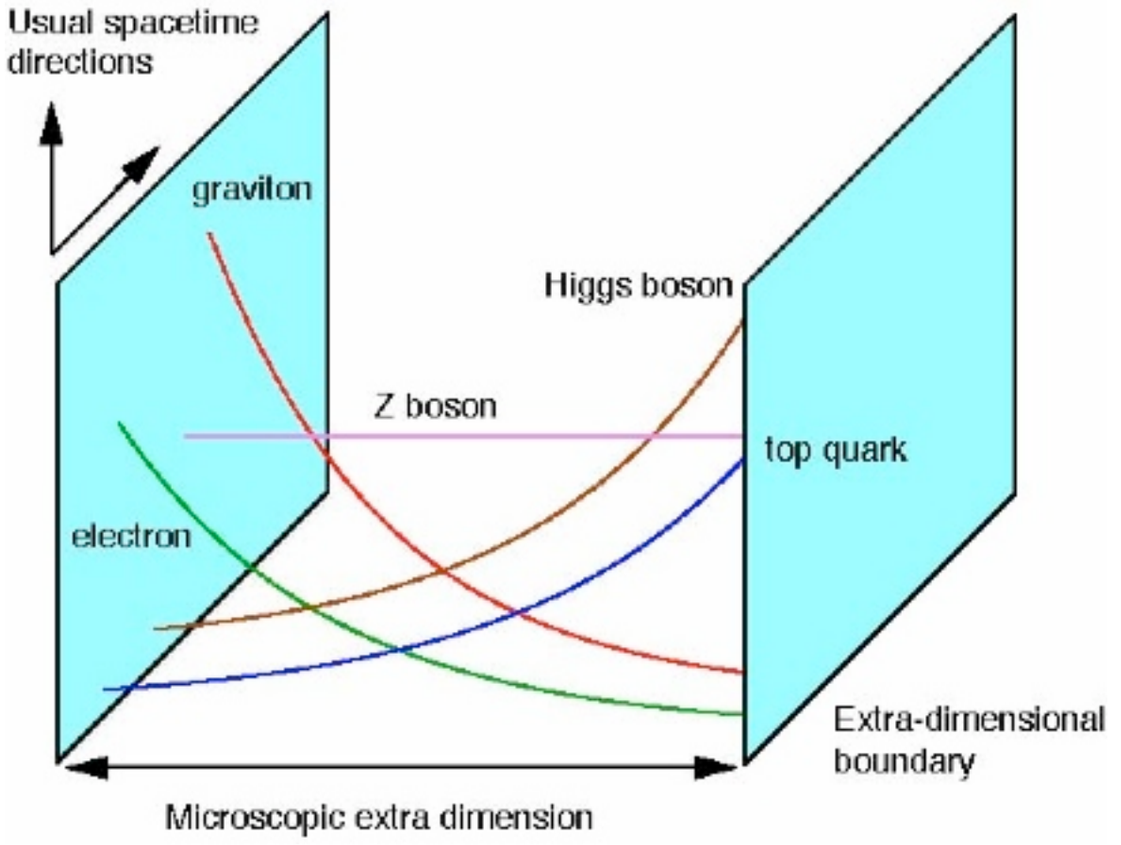
If the Higgs is composite these loops are cutoff at the compositeness scale.

[Georgi, Kaplan]

New strong dynamics!
Higgs is composite, a PNGB
New states

technicolor

technicolor



- Technicolor
- Top colour
- Composite Higgs
- Randall Sundrum
- Little Higgs

Leads to corrections to Higgs properties

$$
\begin{aligned}
\mathcal{L} &= \frac{1}{2}(\partial_\mu h)^2 - V(h) + \frac{v^2}{4}\mathrm{Tr}\left[(D_\mu \Sigma)^\dagger D^\mu \Sigma\right]\left(1 + 2\,a\,\frac{h}{v} + b\,\frac{h^2}{v^2} + b_3\,\frac{h^3}{v^3} + \cdots\right) \\
&\quad - \frac{v}{\sqrt{2}}\,(\bar{u}^i_L \bar{d}^i_L)\,\Sigma\,\left[1 + c\,\frac{h}{v} + c_2\,\frac{h^2}{v^2} + \cdots\right]\begin{pmatrix} y^u_{ij}\,u^j_R \\ y^d_{ij}\,d^j_R \end{pmatrix} + \text{h.c.} + \mathcal{L}^{(4)}, \quad \text{with} \\
V(h) &= \frac{1}{2}\,m_h^2\,h^2 + d_3\left(\frac{m_h^2}{2v}\right)h^3 + d_4\left(\frac{m_h^2}{8v^2}\right)h^4 + \cdots\,, \\
\mathcal{L}^{(4)} &= \frac{g_s^2}{48\pi^2}G^{\mu\nu\,a}G^a_{\mu\nu}\left(k_g\frac{h}{v} + \frac{1}{2}k_{2g}\frac{h^2}{v^2} + \ldots\right) + \frac{e^2}{32\pi^2}F_{\mu\nu}F^{\mu\nu}\left(k_\gamma\frac{h}{v} + \ldots\right)\,,
\end{aligned}
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Parameters	SILH	MCHM5, no light resonances
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[Gillioz et al, 1206.7120]

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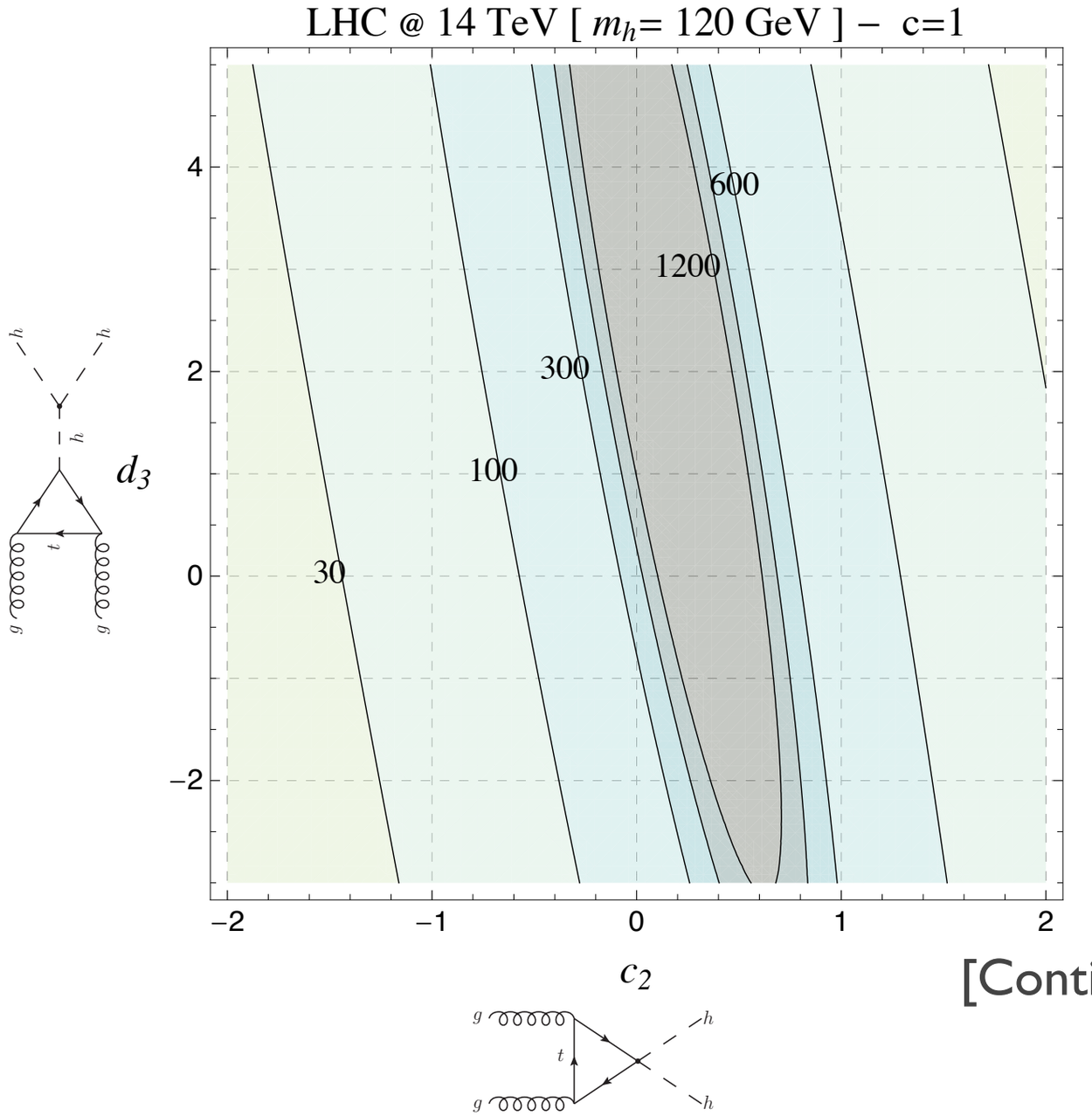
$$\xi = v^2/f^2$$

[Gillioz et al, 1206.7120]

Many BSM models predict corrections to Higgs properties

Composite Higgs models have large double-Higgs production



[Contino et al]

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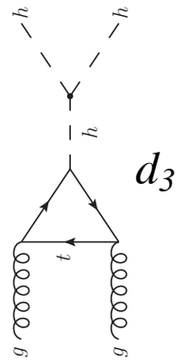
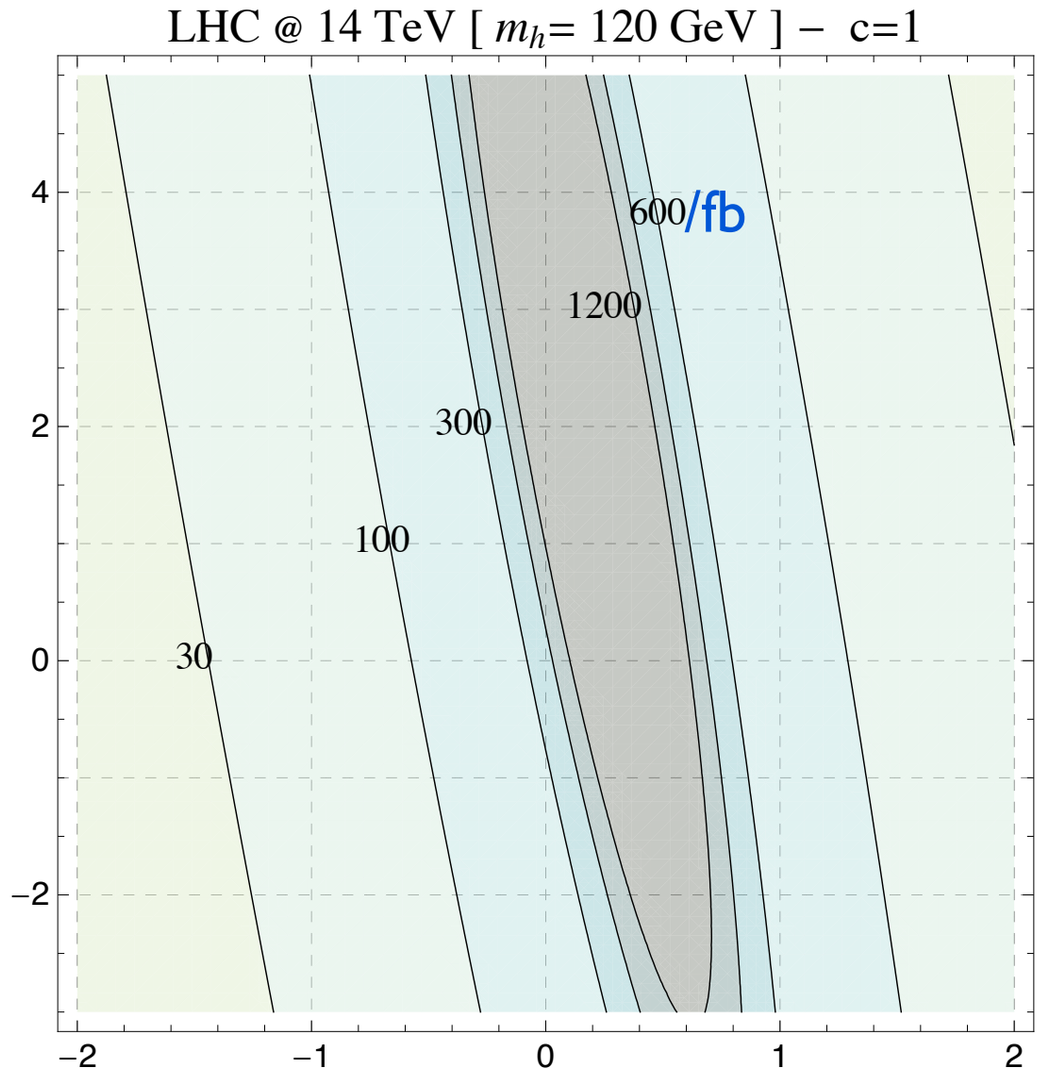
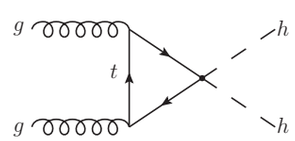
Determination through this method is someway off



d_3

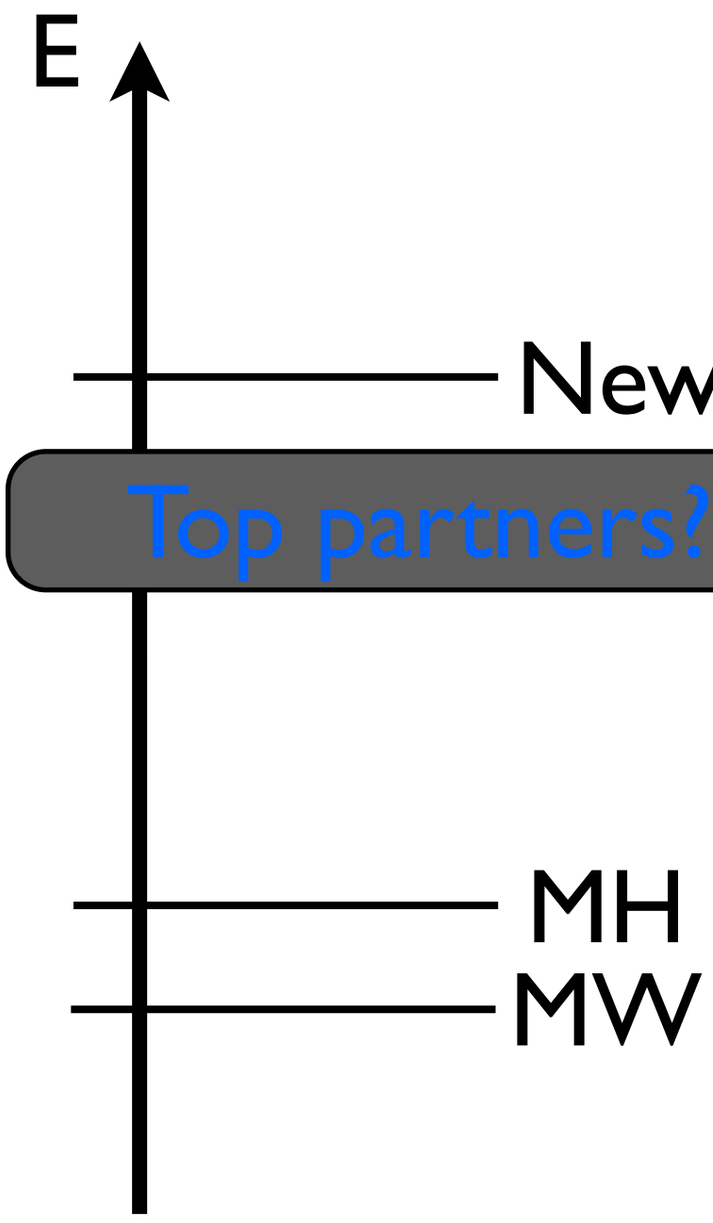


c_2



[Contino et al]

Other states



New electroweak states at ~TeV

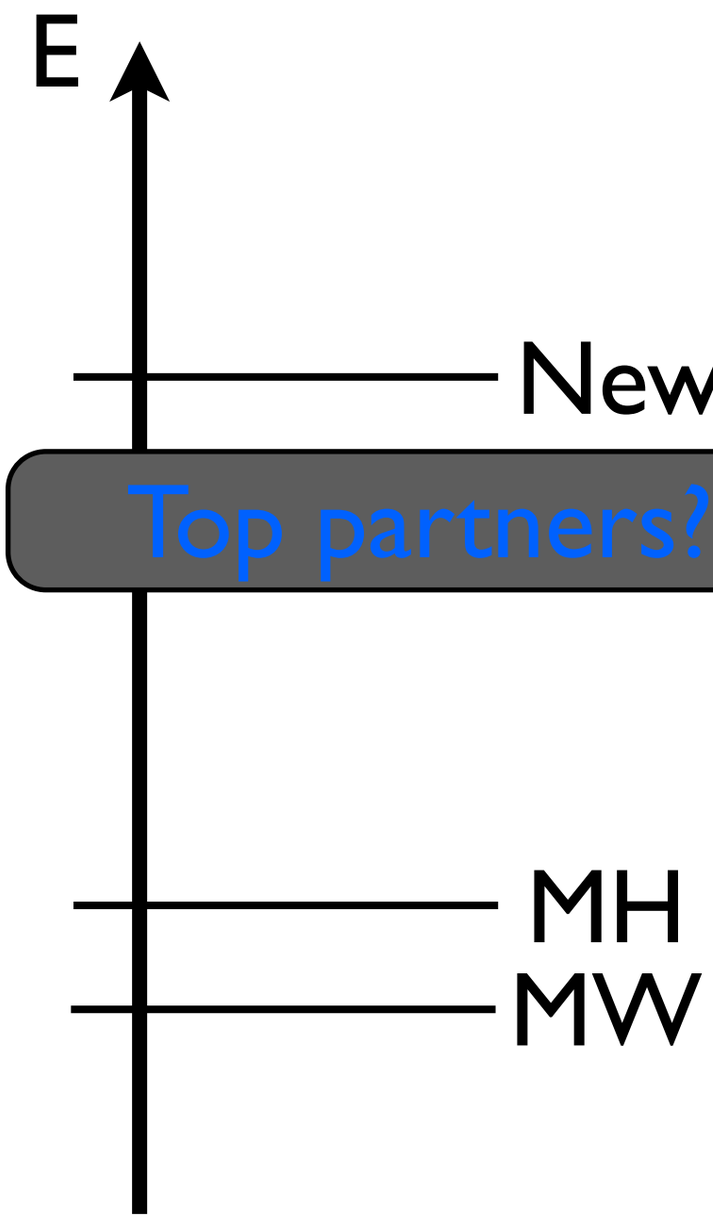
New coloured states (KK gluons)

Vector like fermions (top partners)

Exotic fermions

Top physics altered

Other states



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Properties predicted in particular models, but should search in general, a la simplified susy models

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- No large discrepancies (that we have been told about)

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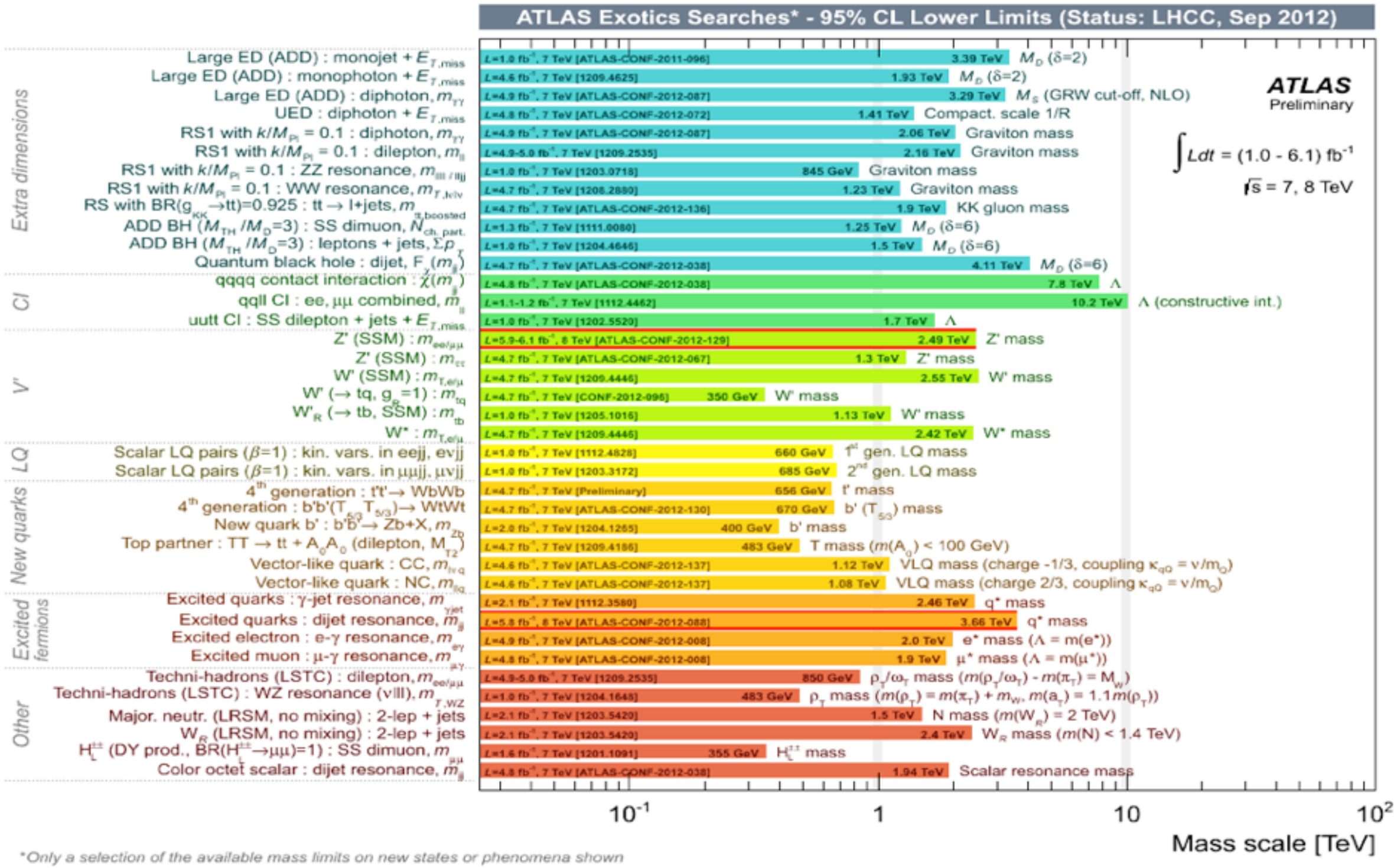
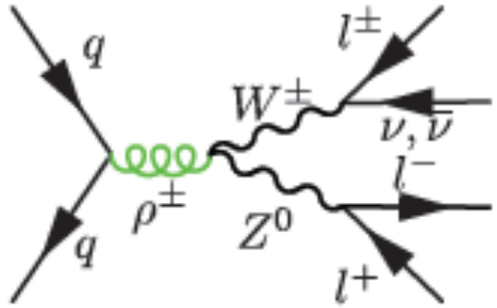
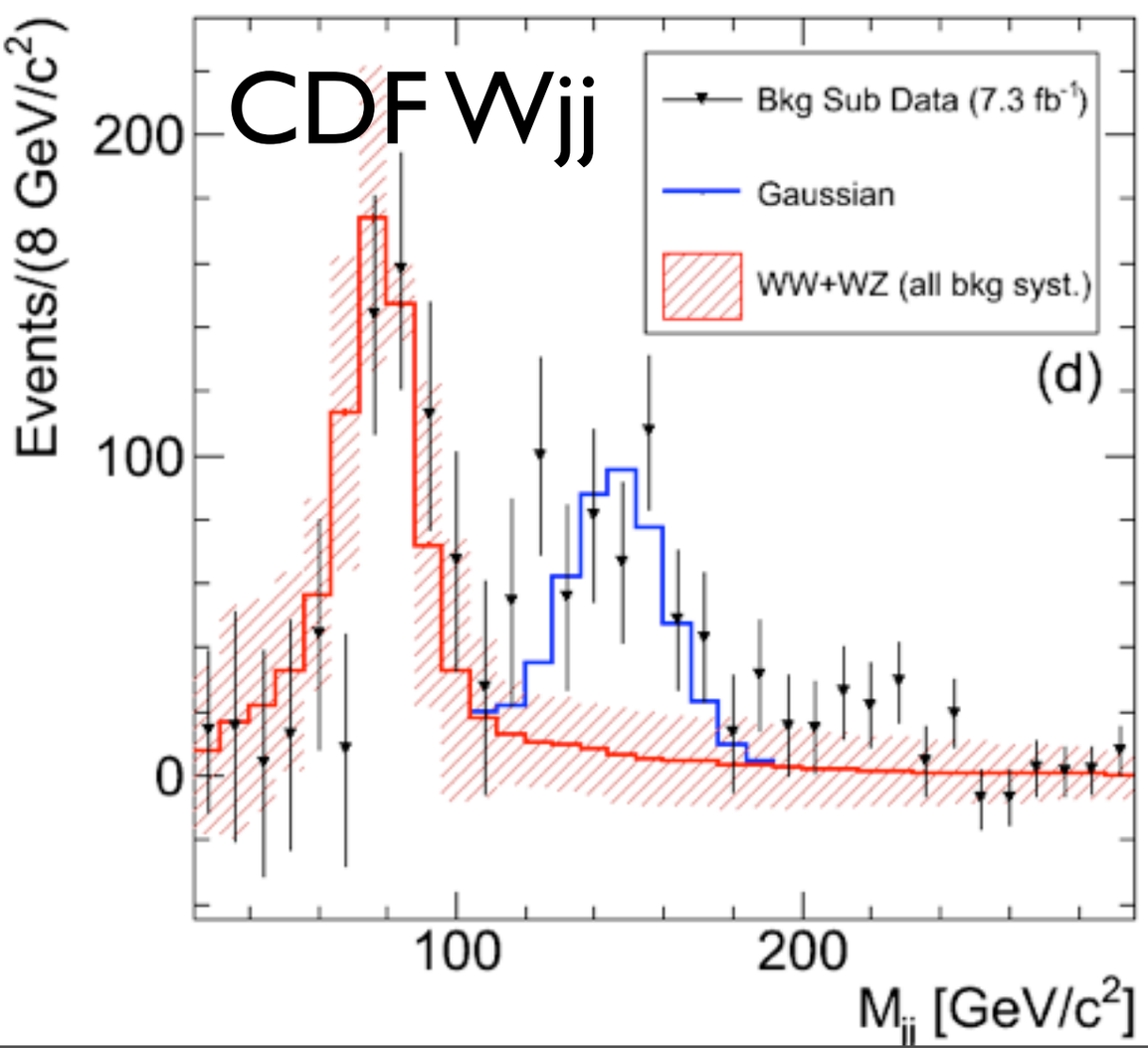


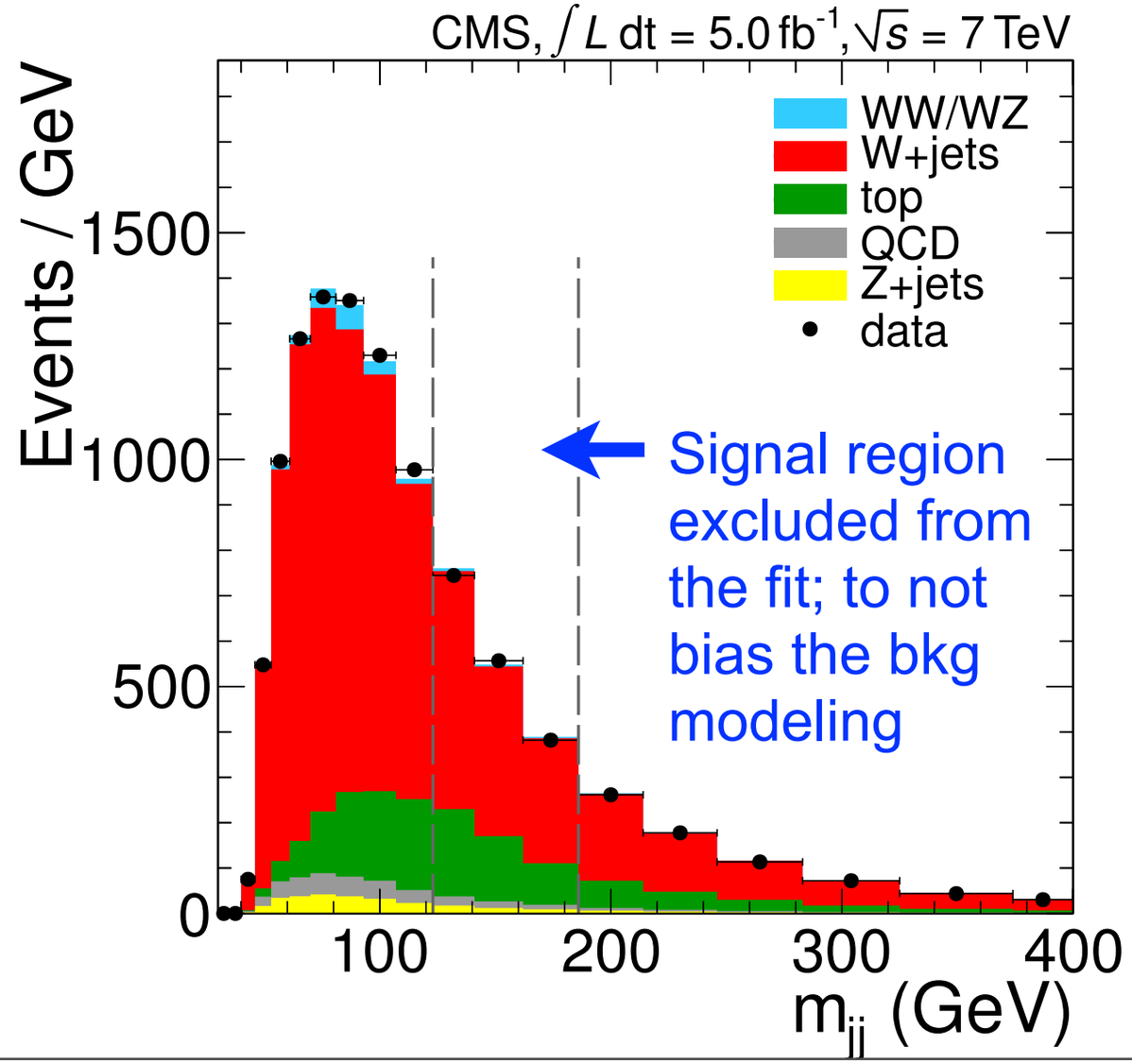
One possible discrepancy?

Possible "TC" explanation

[Eichten et al]



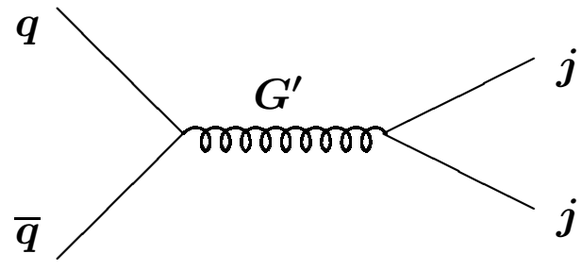




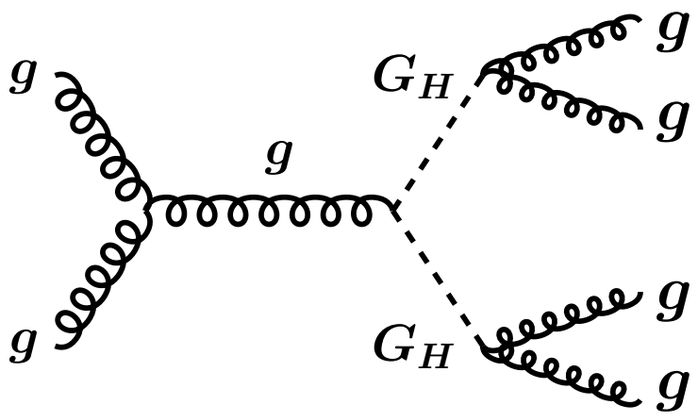
The story moving on

[See B Dobrescu talk at ICHEP]

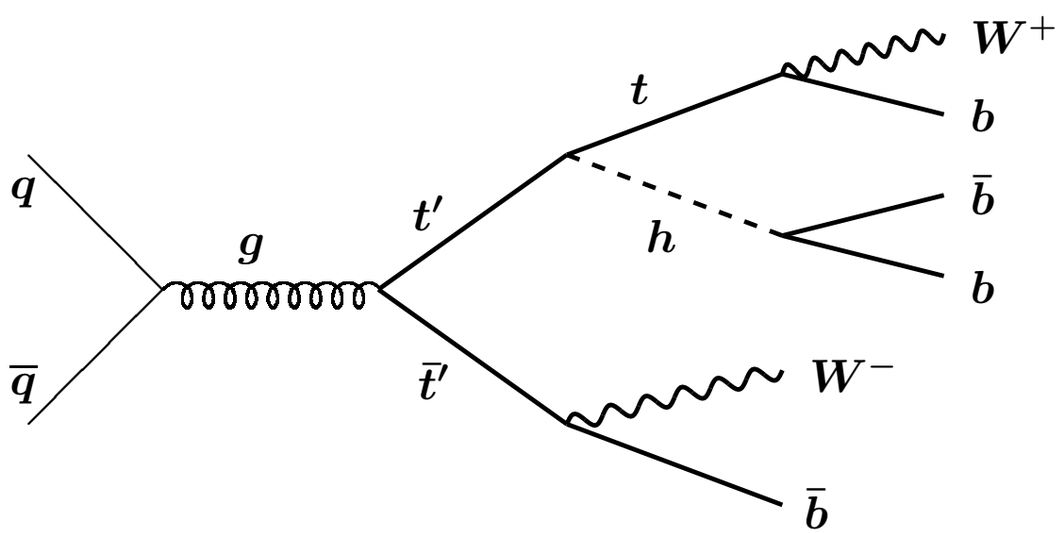
Gluon': di-jet resonances



Colorons: 4-jet resonances



Vector-like quarks (T'):



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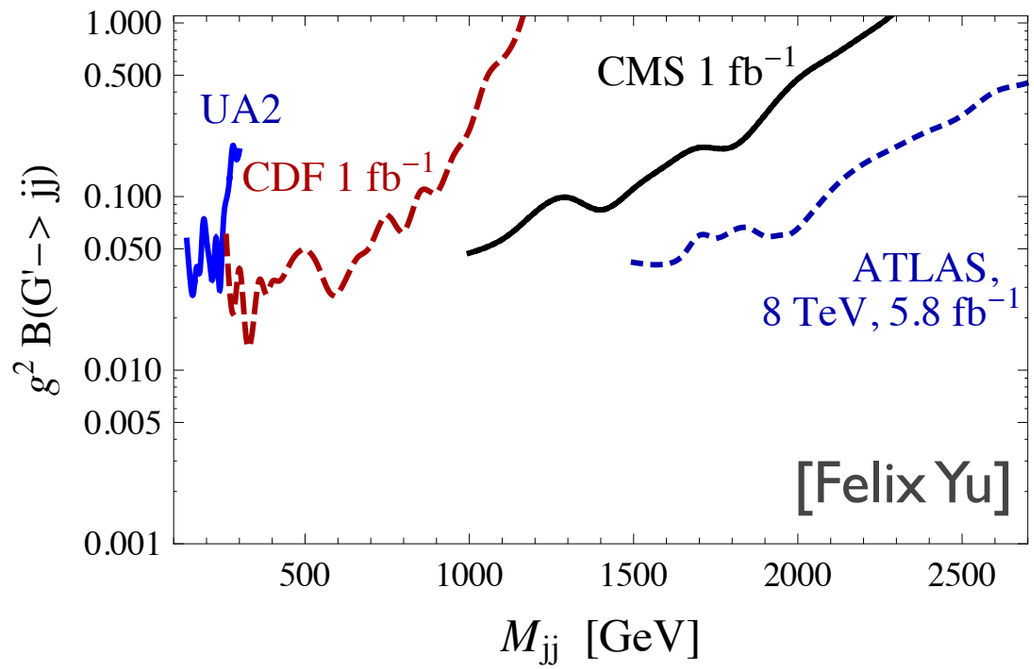

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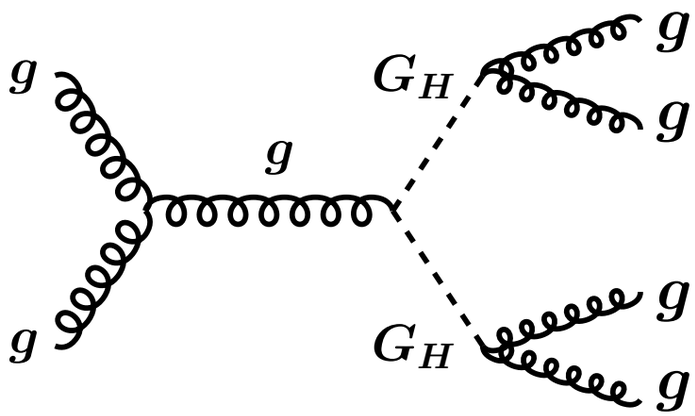

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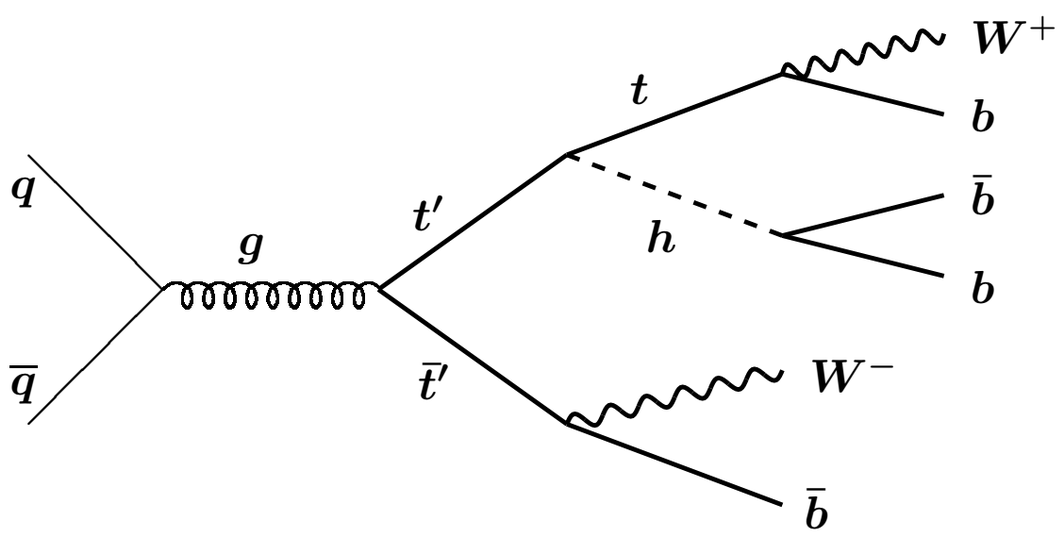


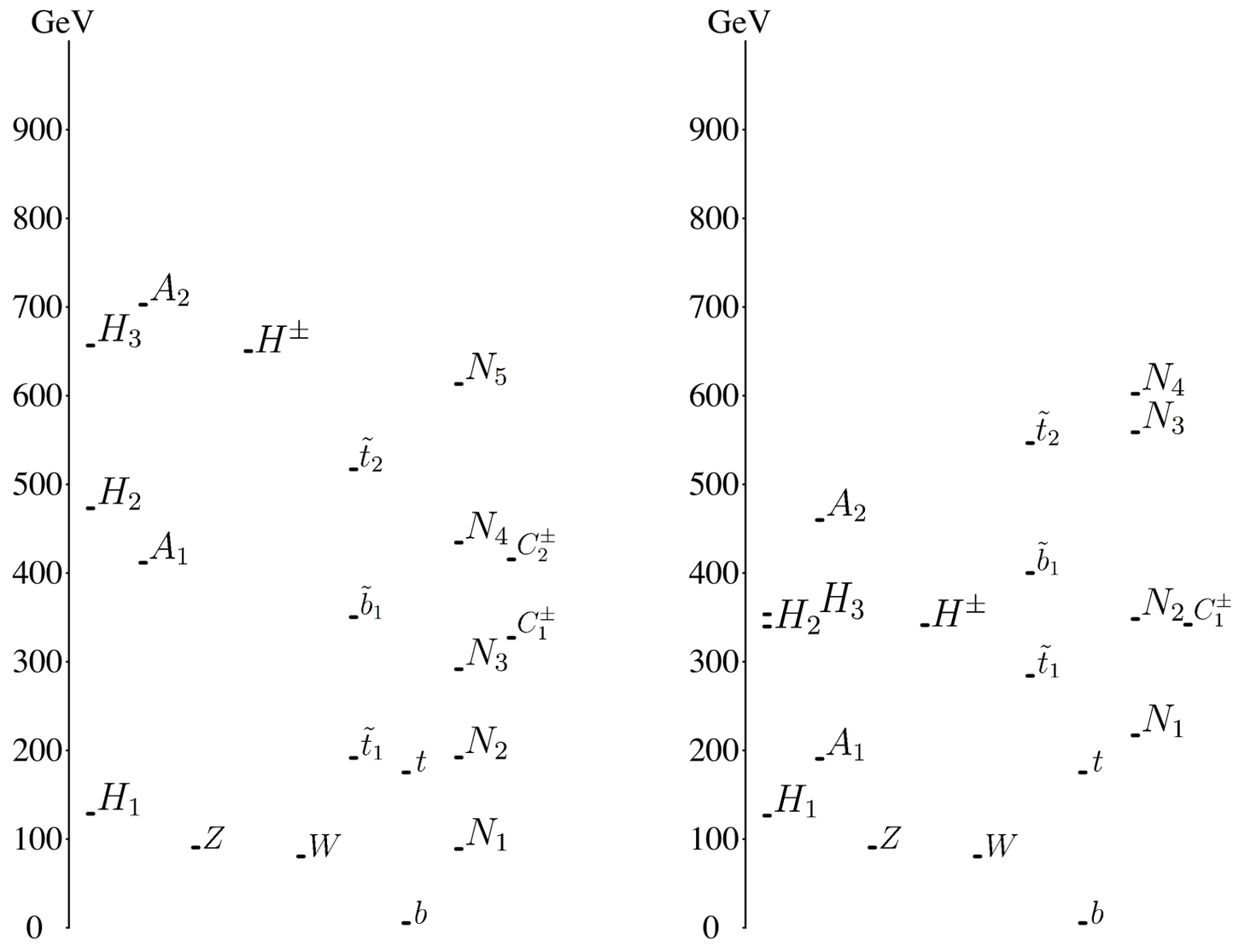
Compositeness *and* SUSY

[Csaki, Randall and Terning]

[Cohen, Kaplan, Nelson]

More minimal SUSY spectrum

Stops and electroweakinos are light



Conclusions(?)

Compositeness provides a solution to the hierarchy problem

Already know v/f<0.3, Higgs results soon tell us more

Many new resonances to go after

Much model building variety

Simple general searches (single production, double production, spin, colour reps, etc etc)